

JPRS-CEN-90-010  
28 AUGUST 1990



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# ***JPRS Report***

# **Science & Technology**

***CHINA: Energy***

19980122 151

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U.S. DEPARTMENT OF COMMERCE  
NATIONAL TECHNICAL INFORMATION SERVICE  
SPRINGFIELD, VA. 22161

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### Primary Energy Output for June

HK0308095590 Beijing CEI Database in English  
3 Aug 90

[Text] Beijing (CEI)—Following is a list of China's total output of primary energy in June 1990, released by CSICSC [China Statistics Information Consultancy Service Center]:

Item	Unit	1-6/90	6/90	% over 1-6/89
Total output (10,000 t of standard coal)		50083.0	9236.0	5.10
Raw coal	10,000 t	51758.0	9637.0	6.10
Crude oil	10,000 t	6815.1	1139.0	1.30
Natural gas	100m cm	75.6	12.9	1.60
Hydropower	100m kWh	588.3	137.3	8.30

### Energy Industry Surges Ahead

40100064B Beijing CHINA DAILY (Economics and Business) in English 9 Jul 90 p 2

[Article by Huang Xiang, staff reporter]

[Text] China's energy industry saw a major upsurge in production and construction during the first half of this year.

According to the Ministry of Energy Resources, coal output topped 509.6 million tons during the six months, 40 million tons above the State target.

The figure represents a 6.33 percent increase over the same period last year and 48.08 percent of the year's targets.

Of the total output, State-run mines under the China National Coal Corporation contributed 247 million tons, which is 6.17 percent over that of last year and represents 54.58 percent of the State target.

The State Council told the coal industry to produce 1.6 billion tons of coal this year, of which State-run mines should contribute at least 452.5 million tons.

Output of cleaned coal for coking reached 34.34 million tons by the end of June, a rise of 4.98 percent over 1989.

The electric power industry generated 295.9 billion kilowatt hours of electricity during the period, 6.9 percent more than the same period last year.

This represents 48.92 percent of the year's target.

Electric power from coal-fired plants registered a 6.44 percent increase in the six months to 237.8 billion kilowatt hours, or 48.59 percent of the official target.

Hydropower stations produced 58.1 billion kilowatt hours of electricity in the six months, a gain of 8.86 percent compared with that of 1989 and 50.37 percent of the year's State target.

Crude oil production by the end of June stood at 68.17 million tons, 360,000 tons more than the same period last year.

The output, which posted a slight increase of 0.94 percent over last year, amounted to 49.4 percent of the year's target.

Natural gas output was 7.33 billion cubic metres during the period, 130 million cubic metres more than in the first half of last year.

The figure was 50.56 percent of the year's requirement.

The country's six large oil and natural gas production fields have fulfilled their quota for the first half of the year.

Daqing Oilfield, China's leading crude oil producer, turned out 27.82 million tons of oil during the first two quarters, an increase of 40,000 tons on last year.

The general improvement of the energy industry also found expression in capital construction in State power projects, according to the State Energy Investment Corporation (SEIC).

Government appropriations available for electric power and coal projects in the six months amounted to 1.8 billion yuan (\$382 million) and 2.5 billion yuan (\$531 million), surpassing the year's target by 4 and 12 percent respectively.

The SEIC is the country's principal State investor in electric power and coal projects. It also splits investment with local governments in joint power and coal undertakings.

**New Plants To Help Power-Short Regions**

40100063A Beijing CHINA DAILY (Business Weekly)  
in English 25 Jun 90 p 4

[Article by Huang Xiang, staff reporter]

[Text] Editor's note: The campaign to push China forward into the 21st century as an economic power has been going on for almost a decade, with the launching of more than 300 major national economic projects. Business Weekly is reporting on the progress of some of the projects which are expected to boost the nation's economic take-off. This is the tenth in the series of reports.

Four major power plants, due to be completed in the next few years, are expected to quench the long thirst for electric power in four power-short areas.

All four projects are coal-fired plants using nearby coal resources, Business Weekly has learned.

The four plants are located near Harbin in Heilongjiang Province, near Changshu in Jiangsu Province, at Shentou in Shanxi Province, and at Daba in the Ningxia Hui Autonomous Region.

The two larger plants, each of a capacity of 1.2 million kilowatts, are in Harbin in northeast China's Heilongjiang Province and in Changshu, a booming city in the country's eastern province of Jiangsu.

The Harbin plant is actually the expansion project of a major local thermal power plant.

The provincial government expects the project to provide enough power to industries in the region including Daqing, China's largest oil producer.

An investment of 1.6 billion yuan (\$340 million), the plant started construction in 1989 with the costs shared between central and local governments.

The project, a key State undertaking in the central government's current agenda, includes two 600,000-kilowatt generating units in the city's No. 3 Power Plant. One of them is due to be completed by 1993.

The No. 3 plant already has two 200,000-kilowatt units.

"The project will be significant to alleviate power shortages for the province's numerous coal mines and Daqing oilfield," said an official with the Ministry of Energy Resources.

Heilongjiang is one of China's major energy suppliers, but as a heavy industry producer, it is also a major power consumer.

The province, with few power plants, has depended on its neighbours to support its power industry, which uses half of its local industrial power consumption every year.

In 1988 it supplied over 20 million tons of coal to other provinces, of which 4.6 million tons went to neighbouring Liaoning and Jilin for power generation.

Since 1986 it has to rely on 1.3 billion kilowatt hours of electric power from outside sources.

With a total capacity of up to 1.6 million kilowatts, experts say the Harbin plant will be one of the country's largest coal-fired plants under construction.

Currently China has its largest completed thermal power plant in Jianbi, Jiangsu Province, with a capacity of 1.525 million kilowatts.

Another 1.2 million-kilowatt-capacity power project is Changshu Power Plant, which started construction in March.

The 2-billion-yuan (\$425 million) project was the result of years of cooperative efforts between local government and the State Energy Investment Corporation (SEIC), the principal state energy investor.

The first-phase construction involves the installation of four 300,000-kilowatt units, with the first one to be finished by mid-1992.

The State corporation provides 50 per cent of the investment while local sources contribute the other half.

The ownership of the power plant is shared according to investment percentage.

In the past the Central Government has only been responsible for investment rather than sharing the ownership of a project.

Corporation officials believe that the Changshu project will greatly relieve the power shortages in East China, which, together with the heavily-industrialized Guangdong in the South and Northeast China, is the country's most power-short regions.

The construction is also the first one in the field to introduce public bidding.

Compared with the above two plants, the Shentou No. 2 Power Plant in Shanxi Province is 200,000 kilowatts smaller in capacity but no less significant, according to energy experts.

Located in northern Shanxi, the small town of Shentou has already witnessed the completion of its first thermal power plant in 1987, a capacity of 1.3 million kilowatts.

The No. 2 plant, which started construction in 1986, will use two Czechoslovakian-made generators.

Each of the generators is able to produce three billion kilowatt hours of electricity in a year.

The construction, which is due to be completed before 1992, is going on as scheduled.

By then, according to a Ministry official, the plant is expected to transmit 1.8 billion kilowatt hours of electricity to Beijing.

Shentou has proved coal deposits of 12.6 billion tons, most of it high-quality coal.

Underground water resources are also in good supply, enough for use in several major power works.

A Ministry source discloses that the government is planning a third coal-fired power project in the area.

With a capacity of 2.4 million kilowatts, the project will be one of the country's largest in the planning stage.

The fourth power plant, which is in Ningxia Hui Autonomous Region, will have capacity of 600,000 kilowatts.

Located in Daba in the central part of Ningxia, 15 kilometres away from the Yellow River, the project is the largest one in northwest China.

The two generators are to be installed by the end of 1991.

The total cost of 700 million yuan (\$150 million) is split between central and local units.

The region boasts the country's fifth largest coal deposit—207 billion tons.

A Ministry official says the plant is actually a first-phase project of a major power undertaking in Daba.

He said the government plans to have a 2.4-million-kilowatt capacity installed by the end of the century.

By then the region, which is among China's poorest, is expected to enjoy a comfortable rise in living standard.

**Energy Minister, State Councillor Zou Jiahua  
Discuss Hydropower Construction***906B0067A Beijing SHUILI FADIAN [WATER  
POWER] in Chinese No 3, 12 Mar 90 pp 3-4*

[Article: "Conscientiously Deal With the Problem of Hydropower's Declining Proportion During Improvement, Rectification, and Readjustment of Internal Structures—Comrades Zou Jiahua [6760 1367 5478] and Huang Yicheng [7806 3015 6134] Discuss Hydropower at the Energy Resource Work Conference"]

[Text] SHUILI FADIAN report: The National Energy Resource Work Conference was held in Beijing in January 1990. State Council member and State Planning Commission minister Zou Jiahua chaired the conference and made an important speech. Ministry of Energy Resources minister Huang Yicheng presented a work report entitled "Do Good Improvement and Rectification in the Energy Resource Industry, Try in Every Possible Way To Increase Labor Productivity and Economic Results." The whole spirit of the speeches and reports by these two leading comrades was of important guiding significance for all sectors of the hydropower industry, which is part of the energy resource industry. Because of editorial limitations at SHUILI FADIAN, we can only report an outline of the spirit of their comments concerning hydropower.

Comrade Zou Jiahua pointed out that the development of energy resources should maintain a specific proportion relative to development of the national economy. On the basis of experiences in foreign countries and practice in China, everyone feels that the elasticity coefficient for energy resources should be maintained above 0.5 and the elasticity coefficient for electric power should be more than 1. We must absorb the experiences and lessons from several major instances of growth and decline since the nation was founded and resolutely overcome the tendency toward hoping for quick results by solidly establishing an ideology of sustained, stable, and coordinated development. While discussing ways to carry out good improvement and rectification in the energy resource industry, Comrade Zou Jiahua emphasized that when readjusting internal structures, we must conscientiously deal with the problem of a declining proportion of hydropower over the past few years. The proportion of investments in hydropower should be increased and we should strive to achieve good hydropower construction, especially construction of medium-sized hydropower stations.

While discussing the current situation in energy resource production and construction, Comrade Huang Yicheng said that China continued to make good achievements in energy resource production and construction during 1988 [as published; possibly means 1989]. Preliminary statistics indicate that projected gross output of primary energy resources in China could reach 1 billion tons, up 4.8 percent from last year. Output of raw coal could reach 1.04 billion tons, an increase of 60 million tons or

6 percent in output from last year. This is particularly true for unified distribution coal mines which increased output by more than 20 million tons or 4.7 percent from last year, the biggest yearly increase in output over the past 10 years. Crude oil output may reach 137.6 million tons and natural gas output 14.4 billion cubic meters, up by 3.6 percent. National electric power output during the first quarter was basically the same as in the same period last year. There was negative growth in the three big East China, Northeast China, and Central China grids but it later increased rapidly each quarter. Projections indicate that it may reach 580 billion kWh by the end of 1989, an increase of more than 35 billion kWh or about 7 percent in power output from last year. Output from hydropower was 116 billion kWh, up 6.3 percent from last year. The total value of output in the nuclear industry is expected to be about 1.5 billion yuan, including more than 600 million yuan in value of output from civilian products, up 20 percent from last year. In the area of electric power construction, over 9,000 MW of new generators 500 kW and larger was placed into operation in 1989, including 8,050 MW in large and medium-sized generators included in state plans, a slight decrease from last year. While discussing difficulties and problems in the energy resource industry, Comrade Huang Yicheng said that there had been serious idleness in hydropower construction enterprises due to insufficient tasks and many enterprises had been unable to pay wages, so their existence and development were in serious straits. The Ministry of Energy Resources understands and is concerned about these problems and has reported them to the State Council and relevant departments. Many areas are finding ways to study and solve them, but a process is required.

While discussing the primary goals of improvement and rectification in the energy resource industry, readjustment of internal structures, and reinforcing weak links, Comrade Huang Yicheng pointed out that there has been a continued decline in hydropower's proportion since the Seventh 5-Year Plan. This does not help rational utilization of energy resources and it has increased pressures on coal and transport. During readjustment, we should try to accelerate the development of hydropower as much as possible, especially medium-scale hydropower. Besides increasing the proportion of investments in hydropower as part of state investments, we also should requisition 0.02 yuan per kWh from the power generated by hydropower for use in hydropower construction. We should organize development companies according to river basins to implement cascade development, independent accounting, and self-"rolling."

When speaking of the need to expend over 90 percent of our efforts on exploiting internal potential and trying in every possible way to improve results and efficiency, Comrade Huang Yicheng pointed out that long construction schedules and high construction costs are common in capital construction. He said that exploiting internal potential in the energy resource industry as well as

increasing efficiency and results are both extremely necessary and entirely possible. The key is making a major change in the ideology and concepts of cadres at all levels and truly focusing our efforts on this area. For the various sectors and enterprises in the energy resource industry, increasing efficiency and results means trying in every possible way to increase output, reduce personnel, and reduce materials consumption. There are two main methods. One is to reinforce management and the other is to rely on technical progress. In the area of capital construction, Comrade Huang Yicheng called for a continued focus on design reform and extension of management experiences from the Lubuge project to reduce construction costs and shorten construction schedules. In particular, we should try to make new breakthroughs in hydropower and coal mine construction. Investments in both coal and electric power construction this year are insufficient. Existing investments should first of all be used to guarantee projects now under construction. Any excess funds should be used to begin new projects. When a project gets under way, it should have guaranteed capital, equipment, and materials and be completed quickly. Only in this way is it possible to increase efficiency and benefits in capital construction.

**Majority of Experts Support Three Gorges Project**  
40100072 Beijing CHINA DAILY (National) in English  
16 Jul 90 p 3

[Text] The nine-day meeting held by the State Council to appraise the feasibility of the Three Gorges dam project ended over the weekend with the majority view supporting the key water-conservancy project on the Yangtze River.

Premier Li Peng announced on Saturday at the closing session of the meeting that a State Council committee would be formed to examine the Three Gorges project.

After its study of the project, the Party Central Committee and the State Council would meet to discuss it. Only with the majority endorsement of the National People's Congress, the country's highest legislative body, can the project begin.

More than 70 top scientists and experts, including those for and against the project, attended the meeting.

The State Council named Zou Jiahua, minister of State Planning Commission, to head the new project-review committee. The deputy directors of the committee are Wang Bingqian, minister of Finance, Song Jian, minister of State Science and Technology Commission, and Chen Junsheng. All are State councillors.

Seventy-six experts, professors, and scholars spoke at the appraisal meeting and most of them favoured the project while some had different views.

### **Yantan Is Model of Rapid, High-Quality, Economical Construction**

906B0066B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 18 Apr 90 p 2

[Article by Feng Dabin [7458 1129 1755], deputy director and senior engineer in the Guangxi Zhuang Autonomous Region Electric Power Industry Bureau: "Yantan Hydropower Station Is Fast, High-Quality, and Saves Investments"]

[Text] Yantan Hydropower Station, located on the middle reaches of Hongshui He in Guangxi, is one of four big "dual-100" (dam height greater than 100 meters and installed generating capacity greater than 1,000 MW) power stations now under construction in China. Now, the towering dam is rising section by section and the surging waters of Hongshui He have again been tamed. This shows that Hongshui He has entered the golden age of a focus on power and will play a key role in reducing the growing power shortage in the South China Grid and promoting industrial and agricultural production.

Hongshui He runs for a total length of 1,050 kilometers through Guizhou Province and Guangxi Zhuang Autonomous Region. Its average yearly flow is 130 billion cubic meters, three times the flow in the Huang He, so it has extremely rich hydropower resources. The total installed generating capacity could reach 12,700 MW and generate over 6 billion kWh of power annually. It is China's third-biggest "hydropower motherlode." Hongshui He is the trunk of the Xi Jiang system in Zhu Jiang [Pearl River] basin. Both banks of Xun Jiang in the lower reaches and the Xi Jiang-Bei Jiang delta region are economically developed regions with dense populations. Agricultural production levels there are relatively high and they contain large and medium-size cities with concentrated industry like Guangzhou, Wuzhou, Nanning, Liuzhou, and others. Development of Hongshui He would enable it to connect to and transmit power to the South China Grid.

In 1978, the State Council approved a program to develop 10 cascade power stations on Hongshui He. Subsequently, three additional debates were conducted in which the State Council in conjunction with the relevant departments called together leaders, experts, and scholars from Guangxi Zhuang Autonomous Region, Guangdong Province, and Guizhou Province for full discussion. Under the conditions permitted by state finances, materials, and technical strengths at that time, a choice was made to proceed first with Yantan Hydropower Station, which could produce rather good economic and social benefits. In 1984, Yantan Hydropower Station was formally included among key state engineering projects.

Yantan Hydropower Station will be a key power station for cascade development of Hongshui He. The maximum dam height will be 111 meters and it would have an installed generating capacity of 1,210 MW in the near

term and generate 5.66 billion kWh of power annually. After Yantan Hydropower Station is completed, it will be able to play a role as a regulation reservoir and enable the downstream Dahua and Etan Power Stations to generate an additional 57 MW of power. When Tianshengqiao and Longtan Hydropower Stations are completed upstream, yearly power output could increase to 8.38 billion kWh. Moreover, construction of Yantan Hydropower Station could provide valuable experience for building high dams upstream at Longtan and Tianshengqiao for extra-large power stations. Static investments for Yantan Hydropower Station would be 1.6 billion-plus yuan, an investment of 1,333 yuan per kW of installed generating capacity, so it is a relatively inexpensive project in China.

Construction of Yantan Hydropower Station and generation of power 1 year ahead of schedule could increase tax and profit accumulations for the state by 250 million yuan, provide electric power guarantees to increase the gross value of industrial and agricultural output by over 14 billion yuan, and reduce the interest on capital by more than 50 million yuan.

Minister Huang Yicheng [7806 3015 6134] of the Ministry of Energy Resources inspected Yantan Hydropower Station in February 1990. He gave a high assessment of the fast pace, good quality, and investment savings at the Yantan project and said it was at the forefront of similar types of power station projects now under construction throughout China.

#### **Work on Yantan Project Proceeding Smoothly**

906B0066A Shanghai WEN HUI BAO in Chinese  
26 Mar 90 p 1

[Article by Zhang Sheren [1728 4357 0086]: "Construction of Yantan Hydropower Station Proceeding Smoothly, Thousands of Hydropower Builders in 5-Year Tenacious Struggle, Over One-Half of Total Investment Completed, Project Construction Achieves Fast Pace, Superior Quality, High Benefits, Low Consumption, May Generate Power 1 Year Ahead of Schedule"]

[Text] After 5 years of tenacious struggle by thousands of hydropower builders, construction of Yantan Hydropower Station, a key state project, is proceeding smoothly. As of 20 March 1990, 53 percent of the total investment had been completed. The project has achieved a fast pace, superior quality, high efficiency, high benefits, and low consumption as well as new breakthroughs and may begin generating power 1 year ahead of state plan requirements that it begin generating power in July 1993.

Yantan Hydropower Station is located in Dashui County in Guangxi Zhuang Autonomous Region in the middle reaches of Hongshui He. It is a key power station in the state's development of 10 cascade power stations on Hongshui He. The first stage of the project will have an installed generating capacity of 1,210 MW and produce 5.6 billion kWh of power annually. It will be one of

China's biggest hydropower stations. The estimated total investment budget is 1.632 billion yuan.

Construction on the main project at Yantan Hydropower Station, which was designed by the Guangxi Electric Power Bureau's Design Academy, began in March 1985. To ensure good construction of this hydropower station, the former Ministry of Water Resources and Electric Power decided to give overall responsibility to the Guangxi Yantan Hydropower Station Project Construction Company in the Guangxi Electric Power Industry Bureau. Open contractual responsibility bids were solicited throughout China for each part of the project. This was the first time this had been done in the history of large and medium-scale hydropower station construction in China. After intense competition, the Chang Jiang Gezhouba Hydropower Project Bureau, Guangxi Hydropower Project Bureau, Longyang Gorge Hydropower Project Bureau, and other capital construction staffs were successful bidders.

There are several prominent achievements in construction of Yantan Hydropower Station:

1. They have achieved a high rate of speed. The Yantan Hydropower Station project blocked the flow of the river 1 year ahead of schedule in progress requirements stipulated by the state, creating favorable conditions for generating power 1 year ahead of schedule in July 1992.
2. They have achieved high quality. The state has already inspected and accepted the excavation of nine primary and permanent projects including the foundation for the plant building and dam, excavation of open canals, and so on as being of superior quality.
3. They have achieved high investment benefits. By the end of 1989, 859 million yuan of investments had actually been utilized, which was ahead of schedule, and they did not exceed budget estimates and made some savings as well.
4. They have achieved low consumption of raw materials. They have already conserved 169,000 tons of cement, 42,000 cubic meters of timber, and 5,545 tons of steel reinforcing bars, which saved 16.45 million yuan in expenditures for the state and reduced project construction costs.

The builders of Yantan Hydropower Station have also made several new breakthroughs which have attracted attention from their colleagues in China and foreign countries. They completed a rolled concrete dam scientific research project for the state during the Seventh 5-Year Plan and created an advanced standard in China of raising a large dam by 25.3 meters per month. In addition, their achievement of pouring 10,619 cubic meters of rolled concrete in 1 day beat the "world record" of 9,497 cubic meters set in 1987 in the United States. They also completed installation and welding of 10.8 meter-diameter pressurized steel pipe, the largest in China and third largest in the world at present, 1 year

and 8 months ahead of schedule, and filled in a blank spot in extra-large pressurized steel pipe construction technologies in China.

After Yantan Hydropower Station is completed and begins generating power, it may contribute to reducing the power shortage in the Guangxi, Guangdong, Yunnan, and Guizhou region.

Photo caption: Yantan Hydropower Station Project Headquarters commander and senior engineer Li Jinwen [2621 6930 2429] (third from left) meeting at the work site for officials from relevant departments to solve construction problems quickly.

### Work Stepped Up on Geheyan Project

906B0066C Beijing RENMIN RIBAO (Overseas Edition) in Chinese 27 Mar 90 p 1

[Article by reporter Gong Dafa [7895 6671 4099]: "Construction of Geheyan Power Station Proceeding Quickly, First Large Hydropower Project on Chang Jiang Tributary Qing Jiang, First Generator Expected To Connect to Grid and Generate Power in 1993"]

[Text] Construction at Geheyan Power Station, the first cascade project on Qing Jiang, the second largest tributary of the middle reaches of China's Chang Jiang, is now proceeding day and night prior to flooding. They have started pouring cement for the generator emplacements in the power plant building and the spillway section of the large dam has already been poured to a height of 85 meters. Progress on the main projects is proceeding faster than planned.

The Geheyan Hydropower Station project began in January 1987. It will have a total installed generating capacity of 1,200 MW, and the first generator is expected to connect to the grid and begin generating power in July 1993.

Project design personnel boldly adopted new technologies and techniques in international hydropower station design to optimize the design. The project will employ a diversion arrangement which combines tunnel diversion with base-pit through-flow. The total construction schedule in the construction design is just 8 years and 3 months, the shortest construction schedule compared to power stations of a similar scale built previously. The four big 300 MW water turbine generators utilized mixed loans from foreign governments and integrated design and production in China and foreign countries. They are at international levels of the 1980's.

Open bidding and selection of superior construction staffs created the conditions for a fast pace and good quality in the project. Thousands of builders from the Gezhouba Project Bureau and from Bureau 18 and the Tunnel Bureau in the Ministry of Railways have created miracle after miracle. In 1987 they took just 11 months to dig a diversion channel with the biggest flow rate in a limestone region of China at the present time and set a

new record in being the first in China to begin building a large hydropower station and block the flow in the same year. In 1988 they took just 60 days to complete the weir for the large dam one-half year ahead of schedule and made the magnificent achievement of excavating the base pit and pouring the large dam in the same year.

According to authorities, Geheyan Power Station is a key construction project in China's plans for large-scale hydropower installed generating capacity in this century. It is a key energy resource foundation project for achieving a quadrupling of the gross value of industrial and agricultural output and will have extremely obvious economic and social benefits. As a key frequency regulation and peak regulation power station in the Central China Grid, Geheyan may bring a fundamental improvement in the quality of power in the Central China Grid and reduce the shortage of power for industrial and agricultural production.

### Jiantiao Estuary Tidal Power Station Feasibility Study

906B0064A Chongqing XIN NENGYUAN [NEW ENERGY SOURCES] in Chinese Vol 12 No 4, 5 Apr 90 pp 5-8

[Article by Chen Yingrong [7115 2019 6855/2837] of the Zhejiang Province Water Conservancy and Hydropower Survey and Design Academy: "Research on Developing Jiantiao Estuary Tidal Power"]

#### [Text] Abstract

This article provides a brief introduction to the natural conditions of Jiantiao Estuary, preliminary configuration of a tidal power station, selection of water turbine types, operating conditions, environmental impacts, engineering economics assessments, and so on, and discusses ways to reduce construction costs in developing tidal power along Zhejiang's coast.

To develop and utilize its abundant tidal power resources, Zhejiang Province has decided to study 10 MW-grade tidal power stations with single generator capacities of 1 MW. Feasibility research on Jiantiao Estuary was conducted with support from the Zhejiang Provincial Science and Technology Commission.

### I. Overview of Natural Conditions

Jiantiao Estuary is located in Sanmen Bay in southeast Zhejiang Province. Its geographic position is 121°34' east longitude and 29°03' north latitude. It is a long, narrow, and winding estuary that runs for a total length of 17 kilometers. The estuary is 300 to 500 meters wide and the water in the estuary is 5 to 10 meters deep. It is located in a subtropical monsoon climate region with average annual precipitation of 1,650 mm, an average annual air temperature of 16.6°C, and a perennial average maximum windspeed of 17.3 meters/second. The maximum tidal range is 7.16 meters and the average



tidal range is 4.18 meters. The average flood tide duration is 6 hours 18 minutes and the average tidal fall duration is 6 hours 7 minutes, so it has regular semi-diurnal tides.

## II. Engineering Geology Conditions

Jiantiao Estuary is a coastal region of low mountains and hills with hillside slopes of 25° to 50° and a divide crest elevation of 8.0 to 450.0 meters. The elevation of the bottom of the estuary channel is generally -12.0 meters, but is -20.0 to -35.0 meters in some locations. The strata distribution is volcanic rock from the upper Jurassic, upper Cretaceous, and other periods. The Quaternary system is mainly Holocene marine facies sedimentary strata with small amounts of Quaternary upper and middle Pleistocene alluvial and profluvial facies sedimentary strata.

For reasons to be explained below, the site chosen for the dam to block the channel for Jiantiao Estuary Tidal Power Station was in the upper reaches at Suomudu and will be called Fenghuang Shan dam. The left and right sides of the dam and the base of the dam at the dam site would be on Quaternary marine facies sedimentary strata. The maximum depth of burial of the river bottom bedrock is about -74.0 meters.

## III. Dam Site Selection and Key Structures

### A. Dam Site Selection

Two factors were considered during dam site selection:

1. The need to rationally utilize the estuary's resources and avoid all possible negative effects of the tidal power station on harbor pier operation and the environment. There is relatively extensive development and utilization of water-borne transport and fishing downstream from Suomudu which has substantial effects on the region's economy and communications. Thus, it would be best if the dam site for the tidal power station was not located downstream from Suomudu.

2. In consideration of the engineering scale and investments, the average tidal fall at Fenghuang Shan is 0.12 meters higher than at Jiantiao station, and although an installed generating capacity of 7 X 3 MW could be built at Huangmen Gorge, more than Fenghuang Shan (5 X 3 MW) and Suomudu (6 X 3 MW), the water surface is narrow (only 200 meters), the water is deep (over 40 meters), the lithology is steep slopes, and the flow rate is large, so unusual specially-designed structures would be required. The technical difficulty would be great, the construction expenditures high, and total investments would also be large. For this reason, Fenghuang Shan and Suomudu were chosen as two representative dam sites to compare actual project configurations.

### B. Key Structures

Key structures at a tidal power station include a power plant, sluices, earth and stonefill dam, locks, and so on.

On the basis of the topographic and geologic conditions at the Fenghuang Shan dam site, there are two programs for the configuration of key structures. They are a river bottom configuration program and bank configuration program.

The river bottom configuration program would place the power plant, sluices, locks, and so on on the river bottom. The main structures for the power station would be made of prefabricated concrete caissons including caissons for power generation, caissons for the sluices, caissons for the body of the dam, a caisson for the locks, a stonefill dam, and so on.

The power generation caissons would be prefabricated reinforced concrete structures containing the water turbine generators and other equipment and would be the power station's power generation building. The caissons would be poured at a prefabrication yard and then floated to the dam site and submerged onto a prepared underwater foundation. Operational steel sluices would be installed on the downstream side of the caissons and would be opened and closed using oil-pressure sluice openers. Steel inspection and maintenance gates would be installed on the upstream and downstream sides and would be opened and closed by gate-type gate openers. The caissons would be 51 meters long and 31 meters high, and the elevation of the bottom of the caissons would be -15.0 meters. The weight of the caissons would be 10,000 tons each (not including the pressure load) and there would be three altogether.

The role of the sluice caissons would be tide containment. They would have operating gates and inspection and maintenance gates. The gate opening dimensions would be 8 meters wide by 6 meters high and there would be a total of 10 openings. The elevation of the bottom of the gate openings would be -7.0 meters. These of course would be prefabricated reinforced concrete structures and would be built in the same way as the power generation caissons. They would be 36 meters long and 44 meters wide and the elevation of the bottom of the caissons would be -10 meters. The operating gates would be made of prestressed reinforced concrete and they would be opened and closed using oil pressure. There would be three altogether.

The dam body caissons would be located on the axis of the dam and would be one of the structures used to block the water flow. To enable regulation of water levels during construction, temporary sluice openings could be installed to allow the flow to pass during construction. After construction is completed, prefabricated reinforced concrete plates would be inserted to block it off. The dam body caissons would be 44 meters wide and 36 meters long. The elevation of the bottom plates would be -5 and -7.5 meters (determined according to variations in the slope of the two banks). There would be two of them altogether.

There would be one lock caisson placed between the sluice caissons and dam body caissons. Its surface

dimensions would be the same as those of the sluice caissons. It would contain a 10-meter-wide lock which could handle peasant boats of about 10 tons. A translational-type gate would be installed on the western end of the lock and would be opened and closed with a hoist-type opener and closer. A steel vertical spinning bridge would be installed on the upper part of the lock for communication purposes.

The earth and stonefill dam would be located between the dam body caissons and original dikes on both banks of the estuary channel. It would be about 150 meters long and the elevation of the lowest part of the dam foundation would be -1.0 meters.

Two programs were proposed for construction, a pile foundation program and a trench excavation and sand replacement program. These two programs can be compared.

#### 1. Pile Foundation Program

This would involve driving 60 X 60 cm square prestressed reinforced concrete piles into the river bottom and then pouring underwater supporting piers on the top of the piles. The supporting piers would serve as a foundation for the caissons after they were put in place and concrete would be poured underwater between the pile tops and caissons to connect the two together. Moreover, a steel plate water retaining wall would be installed on the upstream side of the caissons to prevent dangerous leakage through the foundation. The piles would be friction support piles that would support the horizontal and vertical forces transferred from the caissons.

#### 2. Trench Excavation and Sand Replacement Program

A bottom trench would first be dug in the river bottom to remove soft earth strata and then the bottom trench would be refilled with sand and gravel and then tamped underwater with a tamping boat. Finally, two inverted strata would be placed on the surface layer to serve as a foundation for the caissons after tamping and leveling.

The designs of both of these programs could satisfy stability, leakage, load bearing, and other requirements, they would cost about the same, and they would have similar construction schedules. During their period of operation, however, the pile foundation program would not have problems with uneven subsidence and the construction technologies are more mature. Thus, adoption of the pile foundation is recommended.

The bank configuration program would use a small mountain on the left bank of the dam site to site the power generation plant building, sluices, locks, and other structures. Diversion canals would be dug upstream and downstream and a water retaining dam built in the original river channel to make the tidal flow shift channels. The power station and other structures would be built on the bedrock using conventional "land-based sluice construction" building methods, so there would be

no difference between the power station's structures and those of a conventional hydropower station.

The bank configuration program has the following characteristics:

- 1) It would require substantial earthworks excavation and use conventional construction methods to place concrete hydraulic engineering structures on the bedrock.
- 2) The construction period would be 5 years, 1 year longer than the river bottom configuration program.
- 3) Placing the structures on the banks would cause the original river channel to shift channels and take up several 100 mu of orange groves. The flushing of sediments could force abandonment of several 100 mu of mountainous land, so it would have a definite environmental impact.
- 4) The cross section of the downstream diversion canal would be smaller than the natural river channel, so it could cause additional losses of head and reduce power output by about 3 percent.
- 5) The total investment would be 119.04 million yuan, which is 1.82 million yuan higher than the river bottom configuration program.

Building the river bottom configuration program would take 4 years at a total project cost of 117.2 million yuan. This would include 37.59 million yuan for structural engineering, 36 million yuan for power generating equipment and installation, 8.21 million yuan for metallic structural engineering, 8.895 million yuan for temporary engineering, and 10.79 million yuan in other expenditures.

#### IV. Power Station Operating Conditions and Water Turbine Selection

Jiantiao Estuary Tidal Power Station would operate in conjunction with the Sanmen County and Taizhou Grids.

A tidal power station with unidirectional power generation requires only simple generators and has high efficiency. It uses shorter flow diversion channels and fewer hydraulic structures. Operating heads are higher and construction costs are lower. The time period to power generation is shorter and the electric power is concentrated, so it is more conducive to connection with large grids for additional regulation. A bidirectional power generating tidal power station has a longer time period to power generation, which helps in regulation and recruiting users, but it also involves more complex equipment, lower efficiency, longer flow channels, and more hydraulic structural engineering.

The tide differential on Jiantiao Estuary is rather small, which is not suitable for bidirectional power generation.

With a similar installed generating capacity (five X 3 MW generators), sluice gate widths (80 meters, 10 openings X 8 meters), gate bottom elevations (-7.0 meters, the elevation of the Huang Hai), and so on, power output would be 47.95 million kWh from unidirectional power generation and 47.83 million kWh from bidirectional power generation, a difference of 120,000 kWh between the two. The total investment would be 117.2 million yuan for unidirectional power generation and 126.1 million yuan for bidirectional power generation, a difference of 8.9 million yuan between the two.

Given the actual conditions for this power station, no consideration was given to the dual use of water turbines as water pumps.

Based on unidirectional power generation operating conditions, the main choices for generators are bulb-type generators and full through-flow generators. Bulb through-flow generators are structurally simpler and more efficient. China has experience in producing them and long-term operating experience, and they are technically reliable. Full through-flow generators are a new type of generator. The power generators are placed on the outer edges of the water turbine vanes and the power generation moment of inertia is many times greater than for bulb-type generators, which aids operational stability. The generator structures are compact and plant building construction costs can be reduced by 10 to 15 percent. However, overall generator efficiency is 1 to 2 percent lower than bulb-type generators. Less time has been spent in operational testing and they have not yet formed product series, so few are in use at present. The cost is higher and they are in the research stage in China. Comparisons indicate that bulb through-flow generators should be used at Jiantiao Estuary Tidal Power Station. The single unit generator capacity was chosen at 3 MW. The turbine diameter would be 5.5 meters, the rotation rate 60 rpm, the design head 2.5 meters, and the water turbine flow rate 145 cubic meters/second. The operating pattern would be unidirectional power generation with unidirectional guide blades and fixed blades. The reason is the need to satisfy topographic and water depth requirements at the dam site and to adapt to the total installed generating capacity, power station scale, and current manufacturing levels in China.

## V. Environmental Impact

The main environmental impacts of Jiantiao Estuary Tidal Power Station would be: 1) Effects on drainage of waterlogged upstream farmland; 2) effects on aquaculture resources and aquatic breeding; 3) effects on silt accumulation within and outside of the reservoir.

### A. Effects on Drainage of Waterlogged Upstream Farmland

Some 9,200 mu of farmland above the dam site would be affected. There are a total of 13 enclosed lakes that can now attain the standards of draining waterlogging that occurs once every 5 years. After the tidal power station is built, when flooding and waterlogging encountered once

every 5 years occurs, the reservoir water level would be 2.0 meters higher than during most periods and most of the farmland above the dam site would lose its self-drainage capability. When flooding encountered once every 10 years occurs, no power would be generated, the water level in the reservoir would basically be maintained at natural conditions, and most of the enclosed ponds would still be able to drain water freely. For this reason, new electric-powered drainage stations must be built at nine of the enclosed ponds to drain waterlogging during floods and waterlogging encountered once every 5 years.

### B. Impact on Aquaculture Resources and Aquatic Breeding

The area of surface water in Jiantiao Estuary covers 13,350 mu, 47 percent of it above the dam. Beaches cover an area of about 8,000 mu and are mainly distributed above the dam site. Gross output from beach shellfish breeding at present is 1,304 tons with a value of output of 1.011 million yuan. Artificial collection produces 465.1 tons with a value of output of 338,400 yuan. After the tidal power station is built, it is expected to have the following impacts: 1) Minor effects on fish, shrimp, shellfish, algae, and other biological resources in the sublittoral zone. This point has been confirmed by conditions at Jiangxia Tidal Power Station. 2) There would be a reduction in the area of the tidal zone which could reduce the number of organisms in the tidal zone. 3) It would create excellent conditions for shellfish breeding (mainly yicheng [4898 5855—a type of razor clam], oysters, Philippine baby clams, and maohan [3029 5743—a type of blood clam]). Developing shallow breeding of true oysters and near-river oysters and full utilization of the sublittoral zone could compensate for losses of beach area. The beach inundation time period would be longer, which would help shellfish breeding but have negative effects on breeding young razor clams.

### C. Silt Accumulation Effects Within and Outside the Reservoir

Testing of hydrological and silt conditions as well as two-dimensional format mathematical model calculations indicate that under natural conditions, very little silt enters via the inlet and accumulates in the estuary. There are only two areas above the dam site where the yearly accumulation rate exceeds 0.1 meters. After the tidal power station is completed, with the exception of the area near the outlet of the power station, the current velocity in all other areas would drop (the maximum possible reduction would be 40 percent), so projections indicate that no noticeable accumulation would occur downstream. Preliminary calculations indicate that there may be greater problems with silt accumulation within the reservoir, so more extensive investigations are necessary.

## VI. Economic Assessment and Discussion

Economic assessments involve analyzing a project's inputs (investments and annual operating costs) and

outputs (benefits) from the perspective of the state (society as a whole) to assess its economic rationality.

Jiantiao Estuary Tidal Power Station would have an installed generating capacity of 15 MW and generate 44.94 million kWh of power annually. Deducting power use in the plant and line losses, yearly power output would be 42.7 million kWh. The total project investment would be 117.2 million yuan and construction would

take 4 years. The unit investment per kW would be 7,800 yuan and the unit investment per kWh would be 2.6 yuan.

On the basis of recommended methods in provisional water conservancy and hydropower economic evaluation regulations, provisional regulations, and so on issued by the Ministry of Water Resources and Electric Power and the stipulated range of assumed values, the economic evaluation indices are:

Calculated electricity price (yuan/kWh)		0.3	0.35	0.4	0.45	0.5
Ratio of benefits to expenses	Economic return rate 0.1	0.74	0.86	0.98	1.1	1.23
	Economic return rate 0.08	0.91	1.06	1.21	1.36	1.52

The total cost of the power station would be 5.27 million yuan/year including 3.16 million yuan in basic depreciation costs and 2.11 million yuan in annual operating costs. The

unit cost for power generation would be 0.117 yuan/kWh and the unit cost of power generation would be 0.123 yuan/kWh.

Based on the 3.6 percent interest rate on hydropower project loans, the time limit for project loan repayment under tax exempt conditions would be:

Calculated electricity price (yuan/kWh)		0.3	0.35	0.4	0.45	0.5
Time limit for loan repayment (years)	All surpluses used to repay loan	16	12.6	10.4	9	8
	Two-thirds of surpluses used to repay loan	30	22	17.5	14.6	12.6

This enables discussion of the reliability of the Jiantiao Estuary Tidal Power Station project.

1. The construction cost of this project is rather high and it would not produce much power. Its economic indices are one to two times higher than conventional hydropower stations. The power station would be economically feasible only if the price of the power it supplies is adjusted to 0.4 yuan per kWh. However, Sanmen County lacks conventional energy resources and the power station itself would have scientific and experimental qualities in developing new energy resources, so it cannot be equivalent to regular hydropower stations. Moreover, tidal power is a non-polluting renewable energy resource, there would be no inundation losses within the reservoir, and construction of the dam could facilitate local land-based communication, so we feel that Jiantiao Estuary Tidal Power Station still has development value and should be included in preparatory work plans as soon as possible.

2. The environmental impact would be limited. Changes in the flushing of sediments within and outside of the reservoir would not seriously affect power station operation, downstream shipping piers, and so on. During the next phase, systematic observations and research should be done at the dam site on tides, silt, chlorine amounts, and so on to enable drawing of final conclusions.

3. Design and construction of marine structures is the main technical problem, especially foundation processing of the thick soft earth base layer and construction of floating caissons. This would involve difficult engineering, relatively difficult technologies, and enormous consumption of investments (58 percent of total structural engineering expenditures). For this reason, configuration programs for key facilities at the power station, foundation processing programs, and floating construction of marine structures should be established as special scientific research topics during the next phase to organize cooperation for attacks on key technical problems.

4. Water turbine power generators and metallic structures are quite expensive (118 percent of structural engineering expenditures), so model energy experiments should be conducted for bulb through-flow generators in the next phase to select each parameter, increase power generation results, and reduce equipment manufacturing costs, and we should explore the feasibility of using full through-flow generators and new corrosion prevention technologies.

## VII. Ways To Reduce Construction Costs

Further simplification and improvement of bulb through-flow generators of course are important measures for reducing power station construction costs, but doing these things involves some difficulty. The reasons

are: 1) It is hard to make significant breakthroughs in efficiency, diversion channel dimensions, and so on for bulb through-flow water turbine generators under large flow rate and low head (the design head is only about 2.5 meters) conditions. 2) Because they are located in a seawater environment, higher requirements are placed on materials and cathodic protection measures must be used. 3) Specialized design, manufacture, and production according to concrete conditions is expensive. 4) It is difficult at present to use full through-flow generators to replace bulb through-flow generators, and it is still hard to predict the prospects for their utilization in China.

Another way to reduce construction costs is to improve the configuration and types of hydraulic structures. By using low hills or reefs having a sufficient area for

deploying structures and trying to shorten upstream and downstream diversion channels as much as possible, the expense of earthworks excavation for the bank configuration program could be greatly reduced, which would shorten construction schedules and substantially reduce power station construction costs.

Feasibility research on Jiantiao Estuary Tidal Power Station leads us to believe that construction of a tidal power station on the coast of Zhejiang Province should pay extremely close attention to selecting topographic and geologic conditions, make the greatest possible effort to deploy concrete hydraulic structures on rock foundations, and use conventional construction methods, which could substantially reduce construction costs and obtain better economic indices.

### Plans Made To Update Power Plants

HK31070134 Beijing CHINA DAILY in English  
31 Jul 90 p 2

[By staff reporter]

[Text] China's power plants will have their generating units updated as part of the industry's campaign to raise efficiency during the Eighth Five-Year Plan period (1991-1995).

Top of the list will be the domestically made 200,000-kilowatt coal-fired units, mainstay of the nation's thermal power equipment, while some of the less powerful and overworked equipment will be withdrawn, CHINA DAILY learned yesterday.

Currently there are more than 90 Chinese-made 200,000-kilowatt units in use, which accounted for 20 percent of total installed capacity by the end of 1989.

Some of these units are either running below capacity or subject to sudden breakdown, and accidents associated with them have, in extreme cases, resulted in loss of life.

The industry has called for the new 200,000-kilowatt models to be redesigned and plans to install several devices to ensure safe operation.

For instance, industry figures have demanded that boilers be equipped with automatic fire extinguishers, and turbogenerators with computer-controlled monitoring systems by the end of 1991.

Sources from the Ministry of Energy Resources said more government appropriations are expected soon as the list for technical improvement has been included in the year's general planning of the State Council.

For these generators with a capacity of between 6,000 to 100,000-kilowatts, some will be replaced and some will be overhauled.

A total of 16 million kilowatts of small-capacity generators surpassed their service period at the end of last year, and experts say another 10 million kilowatts will be added to the overworked system by the end of the century.

Those that cannot be eliminated immediately will have major components replaced to prolong their service life.

The two moves are actually a central part of the Ministry's energy conservation effort.

The energy industry has itself been a major power consumer, and is much more inefficient than most of its foreign counterparts.

The upcoming Five Year Plan requires coal consumption in power generation to be reduced by an average three grams per kilowatt up to 1992.

In the case of 200,000-kilowatt generators, per kilowatt coal consumption should be reduced by five grams by 1995.

Present coal consumption for power generation averages about 430 grams per kilowatt.

Experts estimate that if all coal-fired power plants consume 100 grams less of coal in producing one kilowatt hour of electricity, or the level of the advanced countries, the industry will save 50 million tons of coal every year.

As a result, the Ministry suggests the use of large-capacity generators or those above 300,000-kilowatts in capacity.

Before 1994, the Ministry will install two 600,000-kilowatt and seven 300,000-kilowatt Chinese-made generators.

### Development of Cogeneration Facilities Reviewed

906B0070A Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 3, 5 Mar 90 pp 2-4

[Article by Wang Zhenming [3769 2182 6900] of the Beijing Water Conservancy and Electric Power Economics Institute: "Development of China's Heat and Power Cogeneration Industry"]

[Text]

### I. Overview of the Development of China's Heat and Power Cogeneration Industry

#### A. Rise and Development of the Heat and Power Cogeneration Industry

China began large-scale industrial construction in the First 5-Year Plan, and heat and power cogeneration proceeded along with development of the electric power industry. Regional cogeneration plants were established in some emerging industrial regions like Beijing, Baoding, Shijiazhuang, Zhengzhou, Luoyang, Xi'an, Lanzhou, Taiyuan, Baotou, Jilin, Harbin, Fulaerji, and others. This was the rising stage of heat and power cogeneration. Due to the lack of experience and poor planning at the time, the thermal load deviation was rather great, which prevented taking full advantage of the economic benefits of many cogeneration plants at that time. Only after a period of growth in the thermal load did the economic benefits of cogeneration plants increase.

The 1950's to 1960's was a period of large-scale economic construction in China as well as the initial period of the development of regional power grids. The heat supply generator capacity larger than 6 MW that went into operation during this period accounted for 20 percent of the total thermal power generator capacity. The public cogeneration plant capacity accounted for over 80 percent of the heat supply generators placed into operation during that period. This was the period when

the greatest number of heat supply generators and public cogeneration plants were developed.

#### **B. A Trend Toward a Decline in Heat and Power Cogeneration Construction**

Decentralization of industrial deployments during the Fourth 5-Year Plan and no building of tall buildings in urban areas meant that the main developments were in reserve cogeneration plants for factories. Cogeneration plants developed slower, with just 513 MW of heat supply generators going into operation, about 5 percent of the new thermal power capacity placed into operation. Public heat supply generators accounted for just 29 percent and most were reserve cogeneration plants. Construction of cogeneration plants began to grow in the Fifth 5-Year Plan, with 975 MW of heat supply generators going into operation, equal to about 7 percent of new additions to thermal power capacity. Reserve cogeneration plants accounted for 77 percent.

#### **C. Heat and Power Cogeneration Construction Began To Rise Again in the Sixth 5-Year Plan (1981-1985)**

During the Sixth 5-Year Plan, the CPC Central Committee proposed the magnificent goals of quadrupling the gross value of industrial and agricultural output and raising the people's living standards to relatively prosperous levels by the year 2000. They put forth the principle of "combining conservation and development" as an energy resource policy and adopted a series of measures to actively encourage development of heat and power cogeneration.

From 1981 to the end of 1988, a total of 213 cogeneration projects using various types of heat supply generators with a single unit capacity of 3 to 300 MW were arranged, for a total installed generating capacity of 5,800 MW. This included 23 large and medium-sized projects with an installed generating capacity of 3,770 MW located in nearly 100 cities throughout China. By the end of 1988, 2,900 MW of these projects had been completed and placed into operation and produced over 12 billion kWh of power annually. They provided over 7 trillion kcal/h of heat energy, conserved over 4 million tons of standard coal, and reduced particulate discharges by almost 350,000 tons and sulfur dioxide by more than 250,000 tons. This conserved energy resources, helped reduce the electric power shortage, improved the environment, and promoted development of the national economy.

Since the establishment of the Ministry of Energy Resources, extremely close attention has been given to cogeneration construction and a major effort to promote cogeneration construction as an important energy conservation technology has become a policy focus. Development plans and technical policies have been formulated. Moreover, effective industry management has been implemented for a whole series of links through formulation of regulations and guiding principles, compilation of reference designs, systematization of heat

supply generator parameters, construction of cogeneration projects, economic evaluation methods, examination of feasibility research reports, formulation of power and heat prices, and so on.

During this period, centralized heat supplies in urban areas became an important order of the day.

#### **II. Present Levels**

The situation in heat and power cogeneration in China at the end of 1988 was:

Yearly heat supply 511,405,200 GJ, average power consumption rate in heat supply plants 6.1 kWh/GJ, heat supply standard coal consumption rate 39.59 kg/GJ (these figures are for 6 MW and larger generators).

The total capacity in 6 MW and larger heat supply generators is 7,600 MW, equal to 10.4 percent of the total installed thermal power generating capacity. Among the heat supply targets for heat and power cogeneration, industrial heat utilization accounts for about 85 percent of total heat utilization, while household use and heating account for only 15 percent.

Almost half the cities in relatively frigid northeast, north, and northwest China have centralized heat supply facilities. Ministry of Construction data for 1987 showed that the total area of centralized urban heat supply in China was 150 million square meters. Liaoning Province, where centralized heat supply is most developed, has developed centralized heat supplies in 11 cities and 17 county seats which supply heat to an area of 3 million square meters. Heat supply generators 200 MW and smaller that have gone into operation up to now come in the following categories: back pressure generators, bleeder back pressure generators, bleeder generators, steam condenser tapped bleeder heat supply generators, steam condenser circulating water heat supply, and large dual-purpose heat supply-condensing generators.

The largest of the cogeneration plants now operating in China is Jilin Cogeneration Plant with an installed generating capacity of 550 MW. Its biggest industrial steam supply pipe is 700 mm in diameter and the farthest heat supply distance is 8 kilometers. The largest pipe used for civilian heating is 1,000 mm in diameter and the farthest heat supply distance is 10 kilometers.

Popularization of centralized heat supplies in Beijing Municipality at present is just 13.1 percent, while 51.9 percent of its area still receives its heat supplies from scattered small boilers.

#### **III. Characteristics of China's Heat and Power Cogeneration Industry**

##### **A. Emphasis on Heat Planning in Urban Areas**

China is a socialist country that mainly implements a planned economy, so it is possible to develop the heat and power cogeneration industry under unified planning. Practice and experience show that to achieve better

economic results, we must first prepare good heat plans. Most areas of China now carry out heat and power cogeneration construction under unified arrangements in heat plans.

#### B. Development of Each Type of Heat Supply Generator

While large-scale industrial construction was in progress in the 1950's, several large cogeneration plants were built in some industrial regions and they installed several bleeder generators. In the past few years, because of a focus on building cogeneration plants in previously constructed industrially-dense regions to replace small boiler plants built by factories themselves, more back pressure generators were installed. Back pressure generators lead in medium and small-scale cogeneration plants, but they also have a few bleeder back pressure generators and bleeder generators. To solve the heating problems of their residents, several large cities use relatively large capacity steam condenser tapped bleeders for heat supplies and can still restore them to steam condenser operation during non-heating periods. There are now 200 MW generators in operation and a few cities will build 200 MW and 300 MW dual-purpose generators in the near future.

#### C. Transformation of Moderate and Low-Pressure Steam Condenser Generators

For historical reasons, China still has 11,320 MW of moderate and low-pressure steam condenser generators. Although these generators are small, the equipment is outdated, and efficiency is low, they continue to be used because of the power shortage and some are responsible for peak regulation tasks. Most of these medium and small-scale power plants are located near cities, so they have good geographic locations and relatively strong technical forces. They also have some useful structures, so there are now approximately 1,000 MW of moderate and low-pressure steam condenser generators that have been converted to heat supply generators. In regions which require heating, most of these generators have been converted to high back pressure, reduced vacuum, and increased water circulation temperatures to provide residential heat supplies. The actual water supply temperature of the first generators transformed was rather low. Most were under 70°C, so large amounts of water circulated in the heating grids and pipeline networks were very expensive. Recent summaries of experiences show that equipment should be added to raise the water supply temperatures and reduce overall construction costs.

#### D. Categories of Cogeneration Plants

Large numbers of regional cogeneration plants were built during the emergence and early development of heat and power cogeneration in China. Later, there was a shift to mainly developing reserve cogeneration plants for factories. Many years of practice have shown that each type

has its advantages and there is now a major effort to support construction of regional heat and power cogeneration plants.

#### E. Cogeneration Plant Generator Parameters

According to current stipulations in China, high, moderate, and low parameters are classified as:

Sub-critical generators	170 fkg/cm <sup>2</sup> , 555°C
Ultra-high pressure generators	140 fkg/cm <sup>2</sup> , 540-555°C
High pressure generators	90 fkg/cm <sup>2</sup> , 540°C
Sub-high pressure generators	50-60 fkg/cm <sup>2</sup> , 450-480°C
Moderate pressure generators	40 fkg/cm <sup>2</sup> , 450°C
Sub-moderate pressure generators	25 fkg/cm <sup>2</sup> , 350°C
Low pressure generators	10-13 fkg/cm <sup>2</sup> , 300°C

Sub-high pressure generators have only been built and placed into operation during the past few years. They are now the subject of survey research and summarization for improvement, perfection, and systemization.

#### IV. Policies Necessary To Develop Heat and Power Cogeneration

##### A. Energy Conservation Loans

China's various types of construction projects are now being changed from the government allocations of the past to a loan pattern. All regions can apply for low-interest loans to build heat and power cogeneration projects. Total energy conservation loans now account for 30 to 40 percent of total investments and are used mainly for regional centralized heat supplies.

##### B. Provide Equipment and Materials in Plans

After a heat and power cogeneration project has been approved and is included in state plans, besides having access to low-interest energy conservation loans, there can be partially planned supply of part of its equipment and materials to avoid free purchasing in the market and conserve expenditures.

##### C. Capital Raising

To solve the problem of inadequate state capital and use limited capital to build more cogeneration projects, encourage heat users to raise capital, motivate forces in all areas to engage in joint construction, and adopt preferential policies for units which participate in raising capital in the areas of using power, using heat, and so on.

##### D. Tax Reductions and Exemptions

To actively support heat and power cogeneration, the state has adopted tax exemptions for heat supplies to outside units for cogeneration plans and tax reduction measures for their power generation portion to promote development of the heat supply industry.



**E. Cogeneration Generators Should Not Participate in Grid Peak Regulation**

Power supplied to grids by small local and enterprise reserve cogeneration plants should not be included in state directive plans and grids should not deduct power use indices for the power originally supplied by the grids to units which benefit from cogeneration.

**F. Guarantee Fuel for Small Cogeneration Generators**

The planned fuel indices which replace small boilers should be transferred in their entirety to heat and power cogeneration generators and materials departments should give preferential supplies for insufficient portions.

**G. Determining Heat Prices**

China currently adopts a policy of low selling prices and stresses "guaranteeing the principal and very small profits." The determination of heat prices should consider the interests of cogeneration plants, heat companies, and heat users. Heat prices should be allowed to float along with materials prices.

**H. Retain Some Existing Small Boilers and Peak Boilers and Reserve Boilers**

To reduce project construction costs, reserve boilers should not be built in cogeneration plants at the present time. To improve the economy of cogeneration plants, designs should select heat conversion coefficients smaller than 1. For this reason, some larger capacity boilers with better equipment should be retained within the heat supply range of cogeneration plants for use as peak boilers and reserve boilers.

**V. Development Prospects**

China has now attained a preliminary scale after over 30 years of developing heat and power cogeneration, but they are still far from capable of meeting requirements, so the development prospects are extremely broad. China is an enormous latent market for the heat and power cogeneration industry.

**A. Large Heat Requirements in Industry**

According to 1983 statistics, China has 250,000 industrial boilers that produce 530,000 tons of steam, and there are now 400,000 units. Rough statistics indicate that yearly heat supplies from cogeneration plants now account for under 10 percent of industrial heat utilization. Thus, we need to build large numbers of cogeneration plants to replace our existing small-scale boiler plants which provide decentralized heat supplies.

**B. Civilian Household Use and Heating Supplies Have Just Begun To Develop**

The area of structures now implementing centralized heat supplies in northeast, north, and northwest China accounts for only 7 percent of the existing structure area. As people's standards of living have improved over the

past few years, cities which originally did not install heating facilities are now installing heating equipment in new structures, so the range of heat supply is continually expanding.

As for hot water supplies, only a few cities are using them in some public structures, hotels, and buildings used for foreign affairs. In general, very few residents use them. In the long-term view, however, they will certainly grow to an extremely large heat load.

**C. Major Support From Central Authorities**

The "Environmental Protection Law of the People's Republic of China" clearly states that "we should actively extend regional heat supplies in urban areas." The "Provisional Regulations for Managing Energy Conservation" announced by the State Council propose the need to develop heat and power cogeneration for centralized heat supplies. At the National Energy Resource Work Conference convened jointly by the Ministry of Energy Resources and State Planning Commission, and in many documents issued by the State Council and its related departments and commissions, it was especially proposed that there should be active encouragement and support for developing heat and power cogeneration and they formulated concrete principles and policies. At several important conferences, leading comrades of the central authorities have issued a series of important instructions on developing heat and power cogeneration and centralized heat supplies. Recently, the State Council also approved organizing the State Planning Commission, Ministry of Energy Resources and other units into a working group to coordinate development of the cogeneration industry.

All the above shows the broad prospects for the heat and power cogeneration industry in China.

**Huge Inner Mongolian Plant Would Be Largest in Asia**

906B0065B Hohhot NEIMENGGU RIBAO in Chinese  
14 Mar 90 p 4

[Article by Wu Liji [3527 0500 0679]: "Dalad Pit-Mouth Power Plant Has Superior Plant Construction Conditions"]

[Text] China's nationwide power shortage at present is severely restricting growth in the national economy and affecting the people's lives. To solve the power shortage question, superior power source plant sites must be selected to speed up electric power construction and use the minimum investment to obtain the best economic results. The Ministry of Energy Resources has proposed the principle of building energy resource base areas, major efforts to develop pit-mouth power plants, and adopting long-distance power transmission. This is a comprehensive investment policy that is suited to China's national conditions, makes coal transport for power plants try to avoid tying up state railroad capacity, and conserves coal, power, and shipping.

Dalad in Inner Mongolia has superior conditions for building a large pit-mouth power plant. It has abundant water resources and convenient communications. The plant site is broad and flat, and there are superior conditions at the project site and ash dump. It is also located near load centers and cities and towns. Preparatory work for building Dalad Power Plant began in 1984. Over the past 5 years, the North China Electric Power Design Academy cooperated with the Inner Mongolia Electric Power Design Academy in submitting a feasibility research report. After discussion and passing inspection by experts in all fields, it was decided that the plant site for this power plant would be located on a piece of barren ground on the south bank of Huang He. This does not occupy any farmland or involve dismantling and moving. The power plant would get its water from Huang He. The riverbed is stable, there is plenty of water, and the water source is reliable. On-site testing by the State Earthquake Institute, Ministry of Energy Resources Electric Power Consulting Company, and Ministry of Construction Survey and Design Academy as well as national discussion of the engineering geology aspects of electric power construction indicates that there are good geological conditions at the site of the Dalad Power Plant project. The foundation can bear loads in excess of 25 tons, which can satisfy the natural foundation requirements for using big 300 MW and larger generators. The terrain is flat and broad with an average slope of 2.5 percent, so only a small amount of work would be required to level the land. The ash dump would take up low-lying saline land instead of farmland and would be a plains ash dump. The plant site is located between Baotou-Shenshan railroad and Baotou-Shenshan highway. The highway and railway are 2 to 4 kilometers apart, so communications are convenient. Plans by the banner government of Dalad Banner have set aside an area of 10 square kilometers for use by the power plant and they are providing preferential conditions.

For the past 2 years, leading comrades and experts from state administrative departments have inspected the plant site for Dalad Power Plant several times and praised the excellent plant construction conditions there. It is a good plant site for a large power plant which is hard to find in China. They feel that the final goal of possibly installing 2,400 MW in power generation capacity proposed in the preliminary feasibility research report is too small. Instead, it has plant construction conditions to build 5,000 MW, the largest power plant in Asia.

In negotiations with the Ministry of Energy Resources and Energy Resource Investment Company, the Inner Mongolia Autonomous Region People's Government decided on an initial scale of 1,200 MW. They would first build two 300 MW generators and then use large generators with a single unit generating capacity of 600 and 800 MW. The Ministry of Energy Resources has already submitted its proposal for this power plant project to the State Planning Commission.

We can summarize the superior construction conditions for this power plant as the "six nears and one flat." It is near coal sources, just 30-plus kilometers from Dongsheng Wanli Chuan Coal Mine, which has abundant coal resources, good coal quality, and high heat output. It is near railroads and highways, and has convenient communications. The dedicated line for the power plant is just 2 kilometers from Baotou-Shenshan Railroad. It is near load centers. The load center of the west Inner Mongolia grid is at Baotou and the power plant is just 20 kilometers from a key power transformation station in the southern suburbs of Baotou. It is near the ash dump. The ash dump is 7 kilometers from the power plant. It is near water resources. The water line from the diversion outlet on Huang He to the power plant is 17 kilometers long. It is near cities and towns. The power plant is very close to Shulinzhaio, the seat of the Dalad Banner government, and is 30 kilometers from the center of Baotou City. The "one flat" refers to the flat and broad terrain at the plant site.

The investment results at Dalad Power Plant will be good. After discussion of the feasibility research report, based on a construction scale of 1,200 MW in the initial phase, the investment for the power plant would be 2 billion yuan including out-delivery projects. The coal required by the power plant would be supplied by Wanli Chuan Coal Mine. The coal investment would be relatively low, at 680 million yuan. Coal haulage to the power plant would not tie up state rail freight capacity since it can be hauled by truck. The total investment for coal haulage and power transmission would be 2.6 billion yuan. The construction cost for the power plant would be 2,234 yuan/kW, far lower than the cost of construction at other power plants in China.

Operating costs at Dalad Power Plant after it is completed also will be low. Calculated at the current standard coal price of 70 yuan/ton, the power generation cost would be 50 yuan per 1,000 kWh. Thus, if construction of this power plant is organized according to a rational construction schedule and management is strengthened, the project construction cost would be low, as would the production and operating costs.

This power plant would be a base area power plant. It would mainly supply power to north and northeast China. In the early stages of construction, it would mainly supply power to the west Inner Mongolia grid. Subsequent projects would build multi-region ultra-high voltage power transmission lines to the east Inner Mongolia and northeast Inner Mongolia grids to form a huge and powerful Inner Mongolia grid.

#### **Work Now Under Way on Shandong 650MW Plant**

90P60047 Beijing RENMIN RIBAO in Chinese  
26 Jul 90 p 1

[Text] On 25 July, work officially began on Shandong's Heze power plant, a major State construction project. The Heze power plant is a large-scale project and a joint

venture involving State, provincial, and local interests. A feasibility study was undertaken in September 1984. The plant will have a design installed capacity of 650,000 kilowatts. The construction preparatory work has already been completed.

### **Jiaozuo To Be Fully Operational in 1992**

906B0065A Zhengzhou HENAN RIBAO in Chinese  
9 Jan 90 p 1

[Article by reporter Liu Jialin [0491 1367 2651]: "Construction Begins on Third-Phase Expansion Project at Jiaozuo Power Plant, Installed Generating Capacity 400 MW, Total Investment 317 Million Yuan"]

[Text] Construction of the third-phase expansion project at Jiaozuo Power Plant, which has been included in the state's large and medium scale capital construction projects, formally got under way on 20 December 1989.

Jiaozuo has its own coal and is located very close to Shanxi's huge coal deposits. It is connected to all areas of China by rail and highway and has extremely abundant groundwater resources. It is located close to mountain gorges which can serve as ash pits. All these things have created the conditions for building a large thermal power base area. The total planned installed generating capacity at Jiaozuo Power Plant is 1,200 MW. The project's first and second phases were completed and put into operation in 1980 and 1986, respectively. It has produced a total of 32.6 billion kWh of power and increased the value of output for society by nearly 100 billion yuan.

The third phase expansion project is the final project in construction of Jiaozuo Power Plant. It was approved by the State Council on 18 October 1989 for inclusion in the state's large and medium scale capital construction projects for 1989. The installed generating capacity for this phase of the project will be 2 X 200 MW at a total investment of 317.41 million yuan, which will come from state investments and local capital raising. Full completion and startup is expected in 1992.

The Henan Province Second Construction Company and Henan Province Second Thermal Power Company, who fought hard battles in the first and second phases of project expansion construction, are participating in the third phase expansion project construction. The first two phases of the project which they were responsible for building were both completed 4 months ahead of the construction schedule stipulated by the state and both earlier phases of the project were appraised as superior quality projects by Henan Province. They indicated that during construction of the third phase expansion project, they would try to shorten the construction schedule and create a national-level superior project.

### **1200 MW Zhujiang Plant To Be Completed in 1992**

40100064A Beijing CHINA DAILY (Economics and Business) in English 11 Jul 90 p 2

[Article: "Project To Ease Power Shortage"]

[Text] Guangzhou (XINHUA)—Construction of a thermal power plant on the outskirts of Guangzhou, capital of Guangdong Province, is well underway.

A local official said here yesterday that the first phase construction of the Zhujiang Thermal Power Plant, with a total power generating capacity of 1.2 million kilowatts, was scheduled for completion in 1992.

Upon completion, it would transmit 14.4 million kilowatt-hours of electricity a day to Guangzhou, effectively alleviating the city's power shortage.

According to statistics, Guangzhou has added power generating capacity of 380,000 kilowatts over the past few years. However it still cannot meet the needs of its rapid economic development.

According to Mayor Li Ziliu, Guangzhou is building a number of key capital construction projects in the fields of energy development, expansion of communication facilities and processing of raw materials.

**Key Projects Set To Raise Supply of Coking Coal**  
*40100065A Beijing CHINA DAILY (Business Weekly)  
in English 16 Jul 90 p 4*

[Article by Huang Xiang, staff reporter]

[Text] The Ministry of Energy Resources is pushing ahead with construction work at two major coal mines in Shanxi, China's largest coal-producing province.

The two mines are China's largest coking coal production base in Gujiao and Datong Mining Bureau, the industry's leading steam coal supplier, which is being expanded.

Last week Gujiao saw the third of its five planned mine shafts go into operation. This will enable the base to produce an extra 4 million tons of high quality coking coal a year.

Coking coal is widely used and is a badly-needed raw material in the metallurgical industry.

Situated 50 kilometres west of Taiyuan, the provincial capital, Gujiao has proven coal deposits of 4.5 billion tons in a 360-square-kilometre area. Most of the reserves are coking coal.

Five mine shafts and coal-washing plants are to be built in Gujiao, with a total annual production capacity of 16.25 million tons or a quarter of the nation's annual industrial consumption.

With an investment of 3.5 billion yuan (\$744 million), the whole project may take 15 years and 20,000 workers to complete. Construction started in 1978.

At present, the total production capacity in Gujiao is about 10 million tons, or almost 20 per cent of the country's annual coking coal consumption.

Part of the project is financed by Japanese government credit, but official sources decline to give the exact amount.

The project to expand the Datong Mining Bureau involves the construction of two new mine shafts and the expansion of five others with a planned investment of 70 billion yuan (\$1.49 billion).

The seven mine shafts, which are scheduled for completion before 1995, represent 18.60 million tons in increased capacity.

Datong Mining Bureau produced 34 million tons of coal in 1989, 10 per cent of the total output of the China National Coal Corporation.

Covering 1,827 square kilometres, Datong has proven coal deposits of 71.8 billion tons, most of which are of low-sulphur and low-ash content steam coal.

Every day, it supplies 120,000 tons of coal to other regions including foreign countries.

Last month, Yungang Mine in Datong became the country's sole production base for steam coal.

The move to speed up construction work at the two mines is widely seen as an attempt by the government to keep its hold on the international market.

Last year, the industry exported more than 15 million tons of coal and earned the country \$550 million.

But the industry is facing a growing number of complaints—and even some cancellation threats—from foreign clients claiming that coal from China is substandard.

Previously, coal for export—one of the country's most important sources of hard currency—was supplied by a number of sources. Some were locally-run mines where poor management and lack of mechanization produced substandard coal.

### Prospects Said Good for Natural Gas on Shelf of Northern South China Sea

906B0034A Chengdu TIANRANQI GONGYE  
[NATURAL GAS INDUSTRY] in Chinese  
25 Nov 89 pp 11-15

[Article by Peng Shanhuan [1756 0810 3883] of Western South China Sea Petroleum Corporation: "Prospects for Natural Gas on Shelf of Northern South China Sea"]

#### [Excerpts] Abstract

The continental shelf of the northern South China Sea has an abundance of natural gas resources. There are many superior geological conditions to form a large natural gas zone, including large basin area, thick sediment layer, numerous gas-forming layers, high gas intensity, good coverage conditions, high concentrating index, various storage layers, and large-scale, closed-loop development. The prospects are very bright.

The northern continental shelf of the South China Sea has an abundance of natural gas resources. It has excellent geological conditions for natural gas which can be summarized in the following five aspects.

#### Large Basin Area and Thick Sediment Layer

The northern continental shelf of the South China Sea is located in the open ocean south of Guangdong and Guangxi between Taiwan and Hainan. It is approximately 1,300 kilometers east to west and 200-400 kilometers north to south covering an area of 430,000 square kilometers. Five Cenozoic sedimentary basins, including Beibuwan, Yinggehai, Qiongdongnan, Zhujiangkou and Taixinan, have developed in the continental shelf. They are tensile dislocation basins with many similarities as well as unique characteristics. The Beibuwan basin is a continental crust rift-valley basin which contains a variety of oil and gas reserves, similar to the Bohaiwan basin. The Zhujiangkou basin and Qiongdongnan basin are epicontinental rift-valley basins. The structure consists of a lower fault and an upper trough and land on top of sea sediment system. Oil and gas are highly concentrated. The Yinggehai basin is a lip basin at the seam of the Indo-China plate and South China plate. A sustained fast drop caused the formation of large, rocky stratigraphic enclosures. These basins are located at the edge of a continent with compression activity because this is where the Eurasia Plate and the Pacific Plate meet. In the Cenozoic era, it sank, cracked and expanded under the sea many times and formed numerous bulges and pits. There was a great deal of organic sediment at the continental edge. This organic matter was rapidly buried and converted to oil and gas by the fast drop of the crust and the high temperature geothermal effect. Therefore, a continental shelf is the place where oil and gas can be easily formed and concentrated. Thus, it is an ideal site for oil and gas prospecting.

One of the necessary conditions to form a large natural gas area is a large sediment basin. The criterion is that the area of the basin is greater than 10,000 km<sup>2</sup>. The areas of the basins in the region are: Beibuwan basin

28,000 km<sup>2</sup>, Yinggehai basin 50,000 km<sup>2</sup>, Qiongdongnan 45,000 km<sup>2</sup>, and Zhujiangkou basin 175,000 km<sup>2</sup>. These are all large basins. The sediment in these basins primarily comes from the Tertiary Period. It is generally 6,000-9,000 m thick and the maximum thickness is > 15,000 m. Therefore, these basins in the northern South China Sea not only cover wide areas and have thick sediment—essential conditions for a large natural gas reserve—but also have lots of bulges and pits which provide an extremely favorable condition to form, concentrate and store oil and gas.

#### Numerous Gas Deposits and Large Reserves

A natural gas stratigraphic deposit covers a much wider area than an oil deposit. It requires less stringent conditions to generate natural gas and it usually happens over a long period of time, involves great depth and large scale. Natural gas begins with the formation of kerogen as a result of rotting vegetation. From the standpoint of sedimentation, large amounts of natural gas may be present in land, marine and transition sediment layers, as well as in coal-containing layers in marshland. The upper and lower Tertiary systems in the sediment basins in the northern South China Sea can produce natural gas. From the Eocene series to the Pliocene series, there are four sets of gas-producing rocks. There is an abundance of natural gas sources which can be categorized into four types: biologically generated natural gas, natural gas associated with oil fields, natural gas from thermal decomposition of oil, and coal gas.

The upper Tertiary series is generally marine sediment. Due to the fast, deep sinking motion of the crust, there is a 1,328-7,400 m thick sediment layer of mud rock and arenaceous rock. The sedimentation rate is 2.67-7.05 mm/year, which facilitates biological formation of natural gas in shallow layers.

In northern sediment basins in the South China Sea, oil primarily exists in the Eocene series, Oligocene series, and Miocene series. In addition to oil and oil-derived natural gas, large amounts of over-matured natural gas might be formed from thermal decomposition of oil in a high temperature geothermal field. Based on drilling data, the geothermal temperature gradient in the region is 4.21-4.61°C/100 m. Furthermore, due to steep drop in the basin, oil reserves are very deep. Some organic matter is over-matured, forming large amounts of thermally decomposed natural gas. This is especially apparent in oil containing sags such as the Weixinan sag in Beibuwan basin, Yanan sag and central dip in Qiongdongnan basin, Huizhou sag and Wenchang sag in Zhujiangkou basin, and Yinggehai basin.

Based on resources assessment data, natural gas intensity in all basins in the northern South China Sea is quite high. It generally ranges from 825-1,517 million m<sup>3</sup>/km<sup>2</sup> and can be as high as 3,018 million m<sup>3</sup>/km<sup>2</sup> (Table 1). The potential natural gas reserve in these basins is estimated at over 5 trillion m<sup>3</sup>. It is one of eight promising natural gas regions in China.

Table 1. Table of Natural Gas Intensity in Major Strata in Various Basins

Basin	Natural Gas Strata	Intensity (million m <sup>3</sup> /km <sup>2</sup> )
Beibuwan	Eocene series Liushagang formation	2,212
Yinggehai	Pliocene series Yinggehai formation	1,536
	Miocene series Meihai formation	1,538
Qiongdongnan	Pliocene series Yinggehai formation	825
	Miocene series Meihai formation	595
	Oligocene series Yacheng formation	1,517
	Eocene series	1,116
Zhujiangkou	Oligocene series Enping formation	2,117
	Eocene series Wenchang series	3,018

### Good Overlying Strata and High Concentration Factor

Since the molecular weight of natural gas is low and its mobility is high, it requires more stringent conditions to store natural gas than oil. The covering strata must be very tight. Based on the development of these basins in the northern South China Sea, there were three formation stages in the Tertiary period. In the second stage of formation in the Oligocene epoch, ingression began which results in formation of alternate sand and rock strata for storage and covering. The third basin formation stage began in the early Miocene epoch. Large-scale ingression submerged the entire area and mud sediment is the primary component of the strata above the Miocene series. The mud/stone layer is 459-1,726 m thick, creating an excellent overlying cover for natural gas storage in the region.

In the development of the large rift in the northern South China Sea, the sand along the shore and the bioherm in the marine facies of the Tertiary series have excellent permeability. The deep, large rift, faults around the basins and excellent permeability provided a passage for the transfer of natural gas. After natural gas was formed, it first moved upward along the great rift and then moved laterally. Therefore, the concentration and abundance factors are high in the area. For instance, the Yacheng 13-1 field has several billion m<sup>3</sup> per square kilometer and the Wenchang 9-2 field has over 1 billion m<sup>3</sup> per square kilometer in natural gas reserves.

### Excellent Storage Strata and Numerous Large Traps

There are many types of storage bodies in these sediment basins in the northern South China Sea. They are primarily made of sandstone from lakes, rivers, and oceans, reef facies carbonatite, and sedentary products of bed-rock and mountains prior to Tertiary series. These storage bodies are thick and have excellent physical properties. The porosity is generally 14-25 percent and permeability is  $115.48 \times 10^{-3}$ - $346.44 \times 10^{-3}$   $\mu\text{m}^2$ . They are excellent storage strata for natural gas. For instance, the river and lake facies sandstone in the Yacheng, Enping and Zhuhai formations, the offshore fan delta sand bodies in the Liushagang and Lingshui formations, the marine turbulence sand deposit in the Yinggehai

formation, the bioherm in the Zhujiang and Hanshan formations, and weathered lime rock from ancient mountains from the Carboniferous System are excellent storage strata.

[Passage omitted] There are 415 identified structures for drilling. They are divided into pre-Tertiary and Tertiary System traps. There are more than 80 single stratum traps with area > 50 km<sup>2</sup> which provided favorable conditions for enrichment of natural gas.

### Numerous Natural Gas Enriched Regions and Wide Prospecting Areas

Estimating whether an area is rich in natural gas is determined primarily by whether its geological structure and structural characteristics meet the conditions to form a large natural gas field. These conditions are mainly determined by the following four factor: 1) large basin area and high organic content, 2) thick overlying strata and wide lateral coverage, 3) large and undisturbed traps, and 4) thick storage strata with good porosity and permeability. The basins in the northern South China Sea have these characteristics.

Prospecting results show that there is an abundance of natural gas in the continental shelf in the northern South China Sea. In the late 1950's, oil and gas seepage was found along the coast of Yinggehai. Surveys confirmed that natural gas was seeping at 34 sites at Lingtou, Yinggehai, and Sanya southwest of Hainan, something known for over 100 years. In the past decade, oil and gas exploration on the continental shelf of the South China Sea was begun. Within a short period of time and with minimal drilling, we discovered the Yacheng 13-1 natural gas field in the Qiongdongnan basin with a reserve of over 100 billion m<sup>3</sup>. In addition, the Wenchang 9-2 gas field was discovered in the Zhusan dip in the Zhujiangkou basin. In addition, natural gas was also found in structures such as Huizhou 21-1 in the Zhuyi dip and Wei 6-1 and Wei 11-4 in the Beibuwan basin. Natural gas was also found in the Ying 2 well drilled in Yinggehai; it was abandoned because the walls collapsed.

Through drilling, three natural gas enriched areas have been found on the continental shelf:

### 1. Natural Gas Enriched Area in Yanan Depression of Qiongdongnan Basin

The area is surrounded by three deep rifts. Natural gas formed in the deep oil containing sag first moved vertically up along the rift. As it reached the storage strata, or plane of unconformity, it moved laterally to form a natural gas enriched pocket in the trap between the top and bottom wall. There is a series of upper bend structures along the rift, creating two tectonic zones. These structures are located in the vicinity of oil containing sags which facilitates the capture of natural gas formed in the Yanan depression and Yinggehai basin. It is the most favorable area for natural gas prospecting. The large Yacheng 13-1 natural gas field discovered in the region has a gas layer of over 100 meters. A single well produces over 1 million  $\text{m}^3$  of natural gas daily. The unrestricted gas flow is as high as 8 million  $\text{m}^3$ . It is full of natural gas. The gas column height is greater than the closure of the structure and the gas-containing area is larger than that of the trap, indicating an abundance of natural gas in the region.

### 2. Natural Gas Enriched Area in the Southeast Zhushan Depression in the Zhujiangkou Basin

The area is located in the Wenchang oil-producing depression in Zhushan. A series of contemporaneous upper bends and fault blocks was developed along the south Zhushan rift, together with a series of contemporaneous faults. Natural gas formed deep in the oil-producing sag moved vertically straight up to the storage strata and concentrated in various traps. The traps are located in the direction of gas movement which facilitates the enrichment of natural gas. The Wenchang 9-2 gas field has a gas layer of over 100 meters. Pilot production reached 719,800  $\text{m}^3$ . The unrestricted flow is over 1 million  $\text{m}^3$ . It is evident that there is an abundance of natural gas there.

### 3. Natural Gas Enriched Area in Southern Yinggehai Basin

The area carries the characteristics of a gas-rich basin. The organic content primarily came from vegetation. Oil-producing rock is buried deep and is over-matured. The traps include sandstone from river channels and deltas, mud cone and mudrock perforation, and fault blocks which are extremely favorable for the formation and concentration of natural gas, particularly coal gas and thermally decomposed gas. Two wells, Ying 2 and Yuedong 30-1-1A, were drilled. Natural gas was found in both wells in the Tertiary System. However, testing

failed in both wells due to incidents. The natural gas from Yuedong 30-1-1A well has the characteristics of ground pressure gas.

In addition, natural gas reserves were also found in oil- and gas-rich areas such as the Weixinan depression in the Beibuwan basin and the Huizhou depression in the Zhujiangkou basin. It belongs to oil field associated gas and thermally decomposed gas and is mostly located at the top of the oil field. In structures such as Wei 6-1, Wei 10-3, and Wei 11-3 north in the Weixinan sag, gas condensate was found. The Wei 6-1-1 well produces 940,000  $\text{m}^3$  of natural gas, 210  $\text{m}^3$  of oil condensate and 206  $\text{m}^3$  of crude oil daily. The Wei 11-4-north-1 well produces 136,000  $\text{m}^3$  of natural gas, 73.8  $\text{m}^3$  of oil condensate and 489  $\text{m}^3$  of crude oil daily.

The sediment basins in the northern South China Sea have not been widely explored. Natural gas was found by drilling 1-2 sites in a natural gas enriched area and large and medium natural gas fields have been discovered. Among the seismically detected tectonic bands in the continental shelf, more than 10 promising structures and numerous traps other than upper bends have not yet been drilled. Therefore, the future for prospecting natural gas and discovery of large and high capacity gas fields is very bright in the northern South China Sea.

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### Huge Gas Reserves Discovered in Eastern Qaidam Basin

90P60050 Beijing KEJI RIBAO in Chinese  
31 Jul 90 p 1

[Text] The Qinghai Petroleum Management Bureau has recently disclosed that new natural gas reserves totalling some 19.891 billion cubic meters have been discovered in the Tainan gas fields in the eastern part of the Qaidam Basin. This puts Qaidam's natural gas reserves at 28.808 billion cubic meters. The gas fields at Tainan belong to the Quaternary system, are in loose strata, and the gas layers are shallow and thick. To date, drilling has been completed on five wells and there is an unobstructed flow of more than 1 million cubic meters a day.

**Qinshan Set for Final Equipment Tests**

40100068 Beijing CHINA DAILY (Business Weekly)  
in English 30 Jul 90 p 4

[Article by staff reporter Lao Xu: "Testing Time for Nuclear Power Plant"]

[Text] The Qinshan Nuclear Power Plant in East China's Zhejiang Province is entering the final stage of comprehensive equipment testing.

If all goes well, the plant will start operating in nine months' time when it will be linked to the East China power grid to supply 2 billion kilowatt-hours of electricity a year.

An official from the China National Nuclear Corporation (CNNC) said installation of a 300-megawatt nuclear reactor and auxiliary facilities—the first phase—was scheduled for completion at the plant this month.

Work on a 20,000-metre pipeline system was nearing completion and pressure testing of the system had started, he said.

The pressurized water reactor at the power plant had been designed in China and manufactured by the Shanghai Boiler Factory, he told Business Weekly.

Qinshan is China's first nuclear power plant and one of the top priority projects scheduled for completion during the Seventh Five-Year Plan period (1986-90).

The official said quality and safety were regarded as the most important considerations for the project.

The decision to build a nuclear power plant had been made after repeated discussions among nuclear experts, the official said.

"We have been trying to explore the possibilities of cooperation with companies from West Germany, France and Japan for the second phase of the plant," he said.

Experts have approved the feasibility study report drawn up for the second phase of the project which would involve the installation of two 600-megawatt nuclear reactors at the plant.

The overall design for the second phase, drawn up by the Beijing Institute of Nuclear Engineering, had been reviewed by experts and was now awaiting approval from the State Planning Commission, the official said.

The preliminary design for the second phase of construction would be completed by September next year.

The Southwest Centre for Reactor Engineering Research and Design would be responsible for the design of the nuclear steam supply system and the East China Electric Design Institute would take charge of designing the turbine generator, he said.

China's long-term plan for the development of the nuclear power industry remained unchanged.

"We will rely on our own efforts, while seeking cooperation with other countries on the basis of equality and mutual benefit," he said.

"We believe the potential in this field is great and the prospects are bright."

He said China would standardize production of a 600-megawatt pressurized water reactor in order to lower the costs involved in such production in the years ahead.

China's long-term goal was to increase its electricity generating capacity to 240,000 megawatts by the year 2000 from 132,000 megawatts last year.

By that time, the official said, nuclear power would account for 2 percent of the country's energy supply.

He said work on the second phase of construction at the Qinshan plant would enable China to master the techniques of design, equipment manufacture, nuclear technology and safe operation of standard nuclear reactors.



**10-Kilowatt Solar Power Facility Completed**

90P60049 Beijing JINGJI RIBAO in Chinese

3 Aug 90 p 1

[Text] A chinese-designed and installed 10-kilowatt experimental solar power station in Tibet has been completed and put into operation.

This is the largest domestically designed solar power facility in China. It is also the world's highest photoelectric station. The station was designed and erected by the Energy Research Institute of the State Planning Commission and the Sixth Institute of the Ministry of Machine-Building and Electronics Industry.

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